



Environmental Effects of Dredging Technical Notes

TECHNIQUES FOR REDUCING THE COSTS OF SEDIMENT EVALUATION

PURPOSE: This note summarizes recommendations for reducing the costs of sediment evaluation developed by attendees of the Sediment Evaluation Cost Reduction Working Group meeting held 15-19 June 1987 at the Holiday Inn, Vicksburg, Miss. Attendees were representatives of the Federal, State, and international agencies and private concerns and each was considered to be an expert in his field. The Working Group meeting was held under the auspices of the Dredging Operations Technical Support (DOTS) Program. Recommendations contained herein are readily applicable to the sediment evaluation phase of dredging operations.

BACKGROUND: The environmental fate of contaminants contained in dredged material concerns the Corps of Engineers and many other agencies, groups, and individuals who desire to prevent adverse environmental impacts due to the disposal of contaminated dredged material. Characterizing sediments as to the presence and concentration of contaminants in dredged material becomes increasingly more expensive as new contaminants of concern are added to the list of those whose presence must be assayed. The objective of the Working Group was to recommend techniques to reduce the costs of evaluating and characterizing sediments without compromising the quality of Corps environmental impact assessments for dredged material disposal.

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Introduction

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The Corps approach to sediment evaluation in making dredged material management decisions is based on a "Management Strategy for Disposal of Dredged Material," as detailed in Francine et al. (1985). The dredged material disposal strategy employs a "reason-to-believe" approach to sediment evaluation. By using this approach, the number of evaluative tests performed on a

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particular sediment sample depends on the expectation of the presence of contamination and the amount of data required to characterize the sediment. This approach led to the development of a tiered testing scheme--a series of progressive tests and decision alternatives. The testing tier that results in the most intense and comprehensive characterization of the sediment is the terminal tier.

The Corps commitment to the management strategy as a management tool for dredged material disposal, including adequate assessment of the environmental consequences, was outlined in a 23 December 1986 letter to Corps Field Operating Agencies (FOAs) by MG H. J. Hatch, Director of Civil Works. At a long-term dredged material management strategy conference held in Jackson, Miss., in August 1985, the FOAs responsible for dredging operations expressed concern over the potentially high costs involved in implementing the management strategy. The techniques for reducing sediment evaluation costs discussed in this technical note were recommended by members of the Sediment Evaluation Cost Reduction Working Group and are considered to be immediately applicable to sediment evaluation programs. Other recommended techniques generated by the Working Group for reducing costs are being evaluated and, once fully developed and verified, will be made available to the FOAs.

Application of cost-reduction techniques

Most of the nearly 300 million cubic meters of sediment annually removed from our Nation's waterways is uncontaminated or is considered relatively clean and is acceptable for a wide range of disposal alternatives. The evaluation of this material does not require extensive testing and expense. However, the cost of sediment evaluation can escalate rapidly as the number of potential contaminants and the degree of contamination increases. It is for contaminated sediments that cost-reduction recommendations have the greatest potential for application with tangible cost savings. While implementation of some of the recommendations made by the Working Group may initially be more expensive to conduct, cost savings will be realized through improvements in the quality of data collected and, subsequently, fewer requirements for retesting. The other benefit of these recommendations is that FOAs, regulating agencies, and the public will have more confidence in the decisions regarding disposal of dredged material.

Organization of the Working Group meeting

The meeting participants were divided into five groups, each of which was tasked to develop recommendations to improve the cost efficiency of a specific component of the sediment evaluation process: (1) design of the sampling plan, (2) sediment collection and handling, (3) sediment analysis, (4) bio-assessment of sediments, and (5) the economics of sediment evaluation. The procedures recommended in this technical note represent the consensus of the members of the individual groups. Published references are cited where applicable.

The Working Group identified elements of the sediment evaluation process that may help reduce costs while still providing adequate environmental protection prior to dredged material disposal. These are:

- a. Proper design of the sediment sample collection plan, to include:
 - (1) Reviewing historical data.
 - (2) Selecting a scientifically based sediment sample collection scheme.
 - (3) Dividing the project area into management units.
- b. Proper collection and handling of sediment samples, including:
 - (1) Collecting core samples whenever possible.
 - (2) Using proper sediment storage techniques.
 - (3) Compositing samples when appropriate.
- c. Inclusion of quality control and quality assurance in all aspects of the sediment evaluation process.
- d. Use of chemical and biological screening techniques when appropriate.
- e. Use of decision risk analysis to identify and correct weaknesses in the sediment evaluation process.

Ways in which each of these can reduce the cost of testing dredged material are discussed below.

Design of the Sampling Plan

Historical information is very important in the design of a cost-effective sediment sampling plan. Reviewing historical data gives the sampling plan designer the first opportunity to apply the reason-to-believe rationale. A key to the value of historical data is the adequacy and accuracy of the documentation attached to it. To be of value, historical data should

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provide the reviewer with the date and exact location of the sample, how it was collected, and how it was handled or stored. Historical data lacking detailed information may not provide an accurate representation of the waterway to be dredged. Use of incomplete historical data may adversely impact the design of the sampling plan. A poorly designed plan may lead to the selection of a more costly disposal option.

Depending on the sources of contamination and the quality of the data, historical data up to several years old can be used with a high degree of confidence in its validity. Historical information is considered to remain valid for up to 2 years in areas of active contamination, and up to 5 years in areas where there are no active sources of contamination. Older data can be used with caution. For example, when older data are used, the sampling plan designer should consider the effect of time and waterway dynamics on the data's validity and, if necessary, omit the data or include the data with a lower degree of confidence.

Selection of sample collection sites

Pertinent historical data can be applied to provide a presampling characterization of the dredging project and can assist the sampling plan designer in selecting the method to be employed. The sampling methods most often used to characterize sediments are: (1) haphazard, (2) worst-case, (3) random, (4) stratified random, and (5) exhaustive.

The haphazard method is not based on sound scientific principles. It is based on the sampling plan designer's personal biases or is used to satisfy the concerns of various special interest groups. There is a considerable risk of not adequately or accurately characterizing the project area when this method is used. Unfortunately, the haphazard method has been historically employed on some dredging projects. Although it may be a low-cost method, it is not cost effective in the long term and produces data of low confidence value. This method should not be employed on Corps dredging projects, and its use should be discouraged on non-Federally funded dredging projects.

Another sampling method assumed to be low cost is the worst-case method. In this technique, sediment sampling is concentrated in isolated areas identified as likely to be contaminated (referred to as "hot spots") through historical data analysis. Incomplete characterization of sedimentation in the project area is an inherent problem when this method is selected. More complete characterization of the project area may later be required by other regulatory

agencies, thus requiring the collection of more samples. Also, disposal costs may be much higher under worst-case sampling, if the disposal decision was based on data obtained from a small portion of the project that is not representative of the majority of the sediment to be dredged.

The random sampling method is most useful when no reliable historical data are available or when available information indicates that the sediment within the project area is homogenous. Under these circumstances, the project area can be divided into units of equal size and the entire area sampled randomly. The optimum number of samples to be collected can be determined by applying statistical principles, and the units to be sampled can be determined by use of a random number table. Properly employed, random sampling will result in high confidence in the characterization of the sediment.

Similar to random sampling, the stratified random sampling method allows the factors most likely to influence the accumulation of contaminants to be incorporated into the design of the sampling plan. The entire project area is divided into units and sampled, but consideration of historical data permits the sampling intensity to be skewed in the direction of units where contamination is most likely to be found. This method is similar to the worst-case method in that the worst-case area or zone is divided into sampling units. The zone is sampled by randomly selecting sampling units, from within the zone, and collecting the required number of samples for the zone. Stratified random sampling differs from the worst-case method because the entire project area is divided into zones and each zone is sampled. This method permits sediment zones to be characterized with a high degree of confidence, is scientifically sound, and in many cases offers a lower total cost than worst-case sampling.

In the exhaustive sampling method the project area is divided into equal-sized units, and each unit is sampled. This method is not recommended for routine sampling programs because of the high cost involved. It does permit characterization of the sediment with a very high degree of confidence; however, its use may be necessary on projects having widely distributed contamination from a number of sources. The exhaustive method of sampling is usually cost prohibitive and not necessary.

Management units

The concept of dividing the project area into units was introduced in the discussion of sampling techniques. Units are areal or volumetric subdivisions

of the dredging project designed to enhance management of the sediment sampling and dredging programs. Management units can be sized to equate to the volume of dredged material that can be dealt with separately in a dredging operation. For instance, on a project historically characterized as having clean sediment, the management unit may be larger than on a project shown to have localized shoaling containing highly contaminated sediment.

The major cost-savings benefit from dividing project areas into management units is that each management unit or each zone of management units can be characterized independently. Management units or zones permit a dredged material disposal decision to be made for each unit or group of units. Consequently, management units can be managed either individually or collectively, thereby reducing the volume of sediment disposed of in higher cost confined disposal sites.

Collection of Sediment Samples

The sampling plan designer should keep a perspective of the cost of the sample collection operation when selecting sampling sites and determining the number of samples to be collected. Normally, the costs of collecting, handling, transporting, and storing additional samples are minimal when compared to the total cost of the sample collection effort. Therefore, the sampling plan designer should take additional samples in areas in which he suspects potential contamination and store them for further analysis should it be required. By collecting and storing additional samples on the initial effort, the need for a follow-up sample collection effort may be avoided.

Much money can be saved by selecting the appropriate sample collection equipment. Daily costs for several sediment sample collection methods are listed in Table 1. The largest determinant of sampling costs is the size of the vessel required to support the sampling equipment used. Other important factors are the number of personnel required to operate the equipment and the collection time per sample. The data presented Table 1 allow a comparison to be made between two collection methods. For example, in comparing the clamshell dredge and the small vibracore, costs per day are similar. However, when the capabilities of the two are compared, the core sample obtained from the vibracore can be much more useful for detailed characterization of sediment layers than a grab sample from the clamshell dredge. In contrast, if

Table 1
Daily Costs for Several Sediment Sample Collection Methods*

<u>Collection Method</u>	<u>Approximate Cost/Day</u>	<u>Number of Samples/Day</u>
Drilling	>\$10,000	1-2
Large vibracore (>10-ft core length)	\$8,000-\$10,000	2-4
Small vibracore (<10-ft core length)	\$3,000-\$4,000	3-8
Clamshell dredge	\$3,000-\$4,000	6-10
Gravity core	\$1,000	10-20
Surficial grab	<\$1,000	15-40

Note: Table is used courtesy of Mr. Rudd Turner, USAE District, Portland.

* Based on current equipment and labor costs in Oregon.

large volumes of sediment are required from near-surface strata, such as for a full-scale bioassay, a clamshell dredge may be the most efficient sediment collection method.

Storage techniques

Once collected, a sediment sample must be stored in such a manner as to prevent the occurrence of undesirable chemical reactions or volatilization. (For a more in-depth discussion of sediment storage, refer to US Environmental Protection Agency/US Army Corps of Engineers (1981).) Storage techniques and conditions vary with the analytical procedure(s) to be performed on the stored sediment sample. Several short-term sediment sample storage studies have suggested that storage time has no effect on the chemical stability or toxicity of stored sediment (Nebekur et al. 1984; Schwartz et al. 1985; Maleug, Schuytema, and Krawezyk 1986).

The studies on the stability of sediment samples in storage are significant and, when fully developed, sediment sample storage may have the potential to reduce sediment evaluation costs substantially. Proper storage of sediment samples will encourage the collection of a greater number of sediment samples. Samples not required for immediate analysis and the individual components of composite samples could be stored and be readily available if a need for further analysis arises. Proper sample storage will potentially reduce the need to resample a project site, thereby reducing or eliminating the costs of resampling.

Sample compositing

Often, the cost of characterizing a sediment lies not in the number of parameters for which a sample is assayed, but in the number of samples to be assayed. Sample compositing--homogenating several samples into one for analysis--may result in significant cost savings by decreasing the number of laboratory samples analyzed. A carefully conceived compositing scheme can reduce costs and improve confidence in the data obtained by reducing variability. The compositing scheme should be linked to the sampling plan, i.e., a priori to sample collection and analysis. Included in the compositing scheme should be such considerations as where (on boat or in lab) and how samples are to be composited and how individual samples will be split and stored.

One use of composited samples is for sediment screening. Screening is useful for scanning a sediment sample to detect the presence of contaminants. This use may be of great value when insufficient historical data are available to properly apply the reason-to-believe criteria and references are needed to select a sampling method to be employed. Compositing reduces the number of samples required for analysis.

Quality Control/Quality Assurance

All participants in the Working Group meeting expressed the need to ensure adequate quality control in all stages of the sediment evaluation process. Quality control and quality assurance are vital to the success of the Corps' dredged material management program. Quality control involves all the steps that enter into a dredged material disposal decision. Quality assurance is a management function. Quality assurance measures include programming quality control checks into the decision-making process and ensuring that these checks are performed routinely. Quality control begins with the review of historical data and ends with a review of the decision-making factors leading to sediment characterization and the dredged material disposal alternative recommended.

The benefits of a good quality control program are many, but the two most important benefits are increased confidence in management decisions and decreased program costs. Why? Increased confidence comes from having a scientifically sound basis for collecting samples, using the best available

collection method, handling and storing samples properly, and having confidence that the analytical lab performed the analyses correctly. Cost savings are achieved by eliminating resampling, reducing reanalysis, and characterizing the sediment in a manner that permits individual management units to be disposed of in an appropriate manner. Simply stated, quality control and quality assurance increase confidence in results; good results produce good decisions.

Sediment Analysis

The cost of analyzing sediment samples varies widely among contractors. Bids for sediment analysis tend to be linked to the contractor's knowledge of Corps needs; experienced contractors usually submit lower bids than inexperienced contractors. Conversely, caution should be exercised when an extremely low bid is received, as this may indicate that the bidder has limited experience or may not practice the desired quality assurance/quality control. As a precautionary measure, it is recommended that pre-work order performance audits be required.

The use of screening assays may be appropriate when organic contaminant concentrations are of concern. The screens may eliminate the need to analyze for certain organics and, more importantly, may aid in reducing the cost of dredged material disposal if the screens do not indicate the presence of restricted contaminants.

Biological Assessments

No technically defensible cost-reduction techniques are currently available for regulatory biological assessment tests. Biological screens that are now available may be useful in comparing and ranking sediments within a project area; however, only a few have been fully developed. *Daphnia*, mysid, and amphipod sediment toxicity tests have been developed and are considered to be screening tests. Other screening tests that require less sediment and produce results more rapidly are being developed. Biological screens are useful in determining where to concentrate more intensive and expensive studies.

Dredged Material Disposal Decision Risk Analysis

Throughout this technical note the term "confidence" has been used. Though discussed and at times quantified, the use of confidence as a factor in the decision-making process has not been dealt with.

Confidence can be defined as the decision-maker's acceptance of a fact as being true and accurate. Confidence can be modified to the degree to which the decision-maker accepts the fact as true and accurate. In other words, confidence is the absence of doubt, and doubt tempers the degree to which something is accepted as factual.

Applying this definition to the reason-to believe test, each component in the decision-making framework has the potential to be in error. Therefore, each component can be assigned a level of confidence. By evaluating and assigning each component a level of confidence, a degree of confidence in the decision can be determined. The degree of confidence in a decision is equal to the lowest level of confidence for any of the decision components. By assigning a degree of confidence to each decision component, the amount of uncertainty in the decision can be estimated. This is known as a risk analysis.

How will performing risk analysis improve sediment evaluation and reduce costs? First, it will identify weak points in the decision-making process and may allow the weaknesses to be corrected prior to the decision's becoming final. Second, it will serve as an educational tool, allowing weaknesses to be identified, analyzed, and hopefully prevented in the future (thereby improving quality control). Lastly, it can be used to analyze and evaluate several sample plan designs from a viewpoint other than the immediate costs of collecting and evaluating sediment samples.

Summary

Cost savings are achievable, but they will require cooperation from all parties involved in dredged material management. Implementation of the techniques described in this technical note may result in immediate cost reductions. Other techniques are being considered and, if verified, have the potential to substantially reduce sediment evaluation costs.

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